

Statement of

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Mr. Chairman, Ranking Minority Member, and members of the committee: thank you for inviting me here to testify today. My name is Joseph Taylor and I am the James S. McDonnell Distinguished University Professor of Physics and former Dean of the Faculty at Princeton University. I appear today in my capacity as co-chair of the Astronomy and Astrophysics Survey Committee.

As you know, the Astronomy community has a long history of creating, through the National Research Council (NRC), broad surveys of the field at ten-year intervals. These surveys lay out the community's research goals for the next decade, identify key questions that need to be answered, and propose new facilities with which to conduct this fundamental research. The most recent decadal survey, entitled *Astronomy and Astrophysics in the New Millennium*, was released in the year 2000.¹ I have been asked to answer the following questions from my perspective as the co-chair of the committee that produced that report:

1. To what extent, and in what ways, was the Decadal Survey premised on the Hubble Space Telescope having additional instruments that were to be added by a servicing mission? Would the loss of the Hubble cause you to entirely rethink your priorities? Would that change if the *Hubble Origins Probe* or a similar rehost mission is launched?
2. How important are the contributions that would be expected from extending the life of the Hubble Space Telescope when compared to advancements expected from other astronomical programs at NASA to be launched in the next decade, such as the James Webb Space Telescope?
3. Should either a Hubble servicing mission (whether by robot or by Shuttle) or a new telescope such as the Hubble Origins Probe be a higher priority for funding than other astronomical programs at NASA?

In the balance of my testimony I shall address all three questions.

Until recently, the NRC decadal survey was an activity unique to the discipline of astronomy and astrophysics. The most recent survey involved the direct participation of 124 astronomers; moreover, the direct participants received input from many hundreds more of their colleagues. Altogether, a substantial fraction of the nation's astronomers were in some way involved in the creation of the report. By gathering such broad community input, the survey process creates a document that reflects the consensus opinion of the researchers in the field. The value of this activity to NASA and the NSF has been demonstrated in many ways, and most recently by NASA's request for the NRC to conduct similar surveys for planetary science,² solar and space physics,³ and earth science.⁴

¹ *Astronomy and Astrophysics in the New Millennium*, NRC, 2001.

² *New Frontiers in the Solar System*, NRC, 2003.

³ *The Sun to the Earth – and Beyond*, NRC, 2003.

⁴ Study underway - <http://qp.nas.edu/decadalsurvey>

The feature of the decadal Astronomy Survey that distinguishes it from summaries of other fields of science is the prioritized list of missions and facilities that are recommended for construction. This list is put together very carefully; many worthy projects do not make the list, while others are deferred to the next decade. I can assure you that the decision-making process is very thorough and sometimes leaves some “blood on the floor,” metaphorically speaking. One of the factors that make the process possible is the remarkable success of the surveys. The National Science Foundation and NASA have used the survey reports as the basis of their planning processes, and the vast majority of recommended projects from previous surveys have been completed — even if they have sometimes stretched over the boundaries from decade to decade. The completed projects have much to do with the leadership position of our national enterprise in the astrophysical sciences.

The process of priority setting is based on a set of assumptions. For the purposes of this hearing, the most important of these is that priorities from previous decades should be completed. For example, the year 2000 Survey reaffirmed the importance of completing the Atacama Large Millimeter Array that had been recommended in the 1991 Survey.⁵ Along the same lines, the most recent Survey was based on the expectation that a Shuttle Servicing Mission would install in the Hubble Space Telescope new instruments called the Cosmic Origins Spectrograph and Wide Field Camera-3, and would refurbish the satellite in other ways so that Hubble would continue to operate until 2010 — about the time that the infrared James Webb Space Telescope (JWST) is planned to become available.⁶ We were told that this mission, now referred to as SM-4, would cost \$350 million, and it was one of the considerations that led to the final shape of the priority list.

There are a number of strong arguments for keeping the Hubble telescope operational until JWST is ready. The new instruments will expand Hubble’s reach farther into the near-infrared region of the spectrum. This capability will enable the selection of potentially interesting targets that will form much of the basis of the initial JWST research program. The Hubble Space Telescope is still in the prime of its scientific life. Even with some temporarily reduced capacity, astronomers are using it to observe objects that were thought to be beyond any telescope’s capability. Hubble is also important to the nation for reasons beyond its immediate scientific contributions. According to a recent NRC study, nearly one third of all federal support for astronomy research is tied to the Hubble telescope and its affiliated research programs.⁷ NASA, in consultation with the community, plans to transfer these programs to the James Webb Space Telescope when it becomes operational; but the premature loss of Hubble would threaten the continuity and vitality of this research enterprise, and this source of highly trained technical personnel for the nation.

⁵ *A Decade of Discovery*, NRC, 1991.

⁶ The James Webb Space Telescope (then referred to as the Next Generation Space Telescope) was the highest priority recommendation of *Astronomy and Astrophysics in the New Millennium*.

⁷ *Federal Funding of Astronomical Research*, NRC, 2000, pg 54.

We all love Hubble. It is truly a remarkable instrument. That said, the object of my committee's decadal survey was to look ahead and identify the tools that would be needed to continue answering deep questions about the Universe and the most fundamental laws of Nature. In the Survey committee's judgment, in the present decade answers to these questions are more likely to be found in regions of the spectrum outside the Hubble telescope's capabilities. Top Survey priorities such as JWST and the Constellation X-Ray (Con-X) observatory will open large spectral windows on the universe that are simply not available to instruments on the ground. While we can never be sure where the next scientific breakthrough will arise, the future with these missions seems very bright. JWST will be able to observe and examine the very first galaxies that formed in our Universe, and to study the era when the first stars ignited. Con-X will be able to observe how matter and energy behave near black holes — an extreme environment in which the laws of physics have not yet been well tested.

The Survey does not neglect the optical region of the spectrum. Two of the Survey's top three recommendations for ground-based facilities are for new optical telescopes that will observe the universe in new and different ways.⁸ While Hubble can do some things that are unmatched by telescopes on the ground, the choice to move space astrophysics into the infra-red and X-ray regions of the spectrum was one of the difficult decisions that the committee made. In this context, it is difficult to say that the premature loss of the Hubble telescope would significantly alter the Survey's priority list. It is possible that the committee would have given a stronger priority to the Space Ultraviolet Observatory (SUVO), which was omitted from the final priority list; but I do not believe that the rest of our list would have been very different.

Mr. Chairman, the scientific promise of JWST and other Survey priorities lies in the future, while your committee is grappling with decisions that need to be made very soon. Accounting methods and other changes that have taken place at NASA since the completion of the Survey now make it seem very unlikely that a Shuttle servicing mission would cost the science mission directorate as little as \$350 million. However the Hubble telescope is serviced, present cost estimates seem to run to at least \$1 billion — roughly equivalent to that of a second JWST. Such a cost, if borne by the science program, will likely delay a number of other missions that are under development, including those ranked highly in NRC decadal surveys across all of space science.

One option that I have not yet mentioned is to host the Hubble replacement instruments COS and WFC3 on a new satellite like the proposed Hubble Origins Probe (HOP). According to the team proposing HOP, the cost for such a mission would also be roughly \$1 billion, and the telescope would be ready by 2010. The proposal also calls for an additional wide-field imaging camera. Such a satellite offers significant promise; however, to start work on it would in essence insert a new priority into the mission queue, without benefit of the kind of comparative review undertaken in the survey. From the point of view of the survey committee, I believe that neither a \$1 billion servicing mission nor a \$1 billion rehosting satellite should be a higher funding priority than the astronomical science priorities NASA is currently working on.

⁸ The Giant Segmented Mirror Telescope and the Large Survey Telescope

Our nation's science enterprise has been well served by having open, broadly based mechanisms for setting priorities in astronomy, and by closely following the wise decisions made in that way. A project similar to the Hubble Origins Probe could easily be included in the next Astronomy Survey, and would likely be a strong contender then. As you know, I am also a member of the Committee on Assessment of Options to Extend the Life of the Hubble Space Telescope. I heartily endorse that committee's recommendation that NASA should pursue a Shuttle servicing mission to Hubble so as to accomplish the objectives of the planned SM-4 mission. However, I do *not* favor such a plan, much less the launch of a new satellite to host Hubble's replacement instruments, if it would require major delays or re-ordering of NASA's present science priorities. With such a course of action, I believe that NASA would squander the excellent reputation for scientific judgment and leadership that it has so rightly earned over the years.

I should stress that these opinions are my own, informed by my work on the survey and other advisory committees and by conversations with many colleagues.

Thank you for your attention, and I would be pleased to answer questions.